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(54) **OPERATION OF A DISCHARGE LAMP**

BETRIEB EINER ENTLADUNGSLAMPE

FONCTIONNEMENT D'UNE LAMPE A DECHARGE

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(56) References cited:
**EP-A- 0 825 807** **EP-A- 0 825 808**
**US-B1- 6 232 725**





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## Description

**[0001]** The invention relates to a method for operating a discharge lamp including two electrodes, the method comprising applying to the electrodes an alternating current (AC). The invention relates equally to a driver for operating a discharge lamp, to a software program supporting the operation of a discharge lamp, and to a lighting system comprising such a discharge lamp.

**[0002]** High Intensity Discharge lamps are known from the state of the art. Such discharge lamps comprise a tube containing an inert gas or vapor. Further, two electrodes protrude into the tube. For operating the lamp, a suitable alternating current is supplied to these electrodes such that an arc is established and maintained between them.

**[0003]** One special type of high intensity discharge lamps is the Ultra High Performance (UHP) lamp, which may employ e.g. mercury vapor and tungsten electrodes. A common electrode construction in UHP lamps consists of a tungsten rod on which a tungsten coil is positioned. UHP lamps are used for example for projection applications, in which the optical demands on the display require arc lengths in the order of 1mm, The electrodes in UHP lamps reach temperatures close to or even above the melting point of pure tungsten. These temperatures are required to allow thermal emission of electrons in case of a highly contracted high pressure mercury arc and to avoid e.g. arc jumping. Some approaches have been made to directly influence the temperature of the electrodes in such a lamp. For example, EP 0 825 807 A2 suggests a way of forcing one electrode to reach a higher temperature than the other electrode, with the aim of causing particles in the fill gas of the lamp to be deposited on the cooler of the two electrodes when the lamp is extinguished. The temperature of the electrodes also influences the stability of the discharge arc. Should the discharge arc become unstable, a noticeable flickering may occur. US 6,232,725 B1 suggests a way of re-shaping the lamp current to cause in increase in electrode temperature and thus to stabilize the discharge arc. Generally speaking, however, if the electrodes of a gas-discharge lamp become too hot, a so called "burning back" of the electrodes occurs. As a result, the gap between the electrodes is increased, reducing the performance in optical systems. Such a "burning back" is a common reason for poor lamp maintenance. Therefore, a careful design and operation of UHP lamps are necessary, in order to guarantee a well defined electrode temperature. The same requirement may equally be given for other kinds of discharge lamps.

**[0004]** A problem in providing the optimal temperature for the two electrodes of a discharge lamp may arise in particular, in case the two electrodes reach different temperatures, Such a situation may also occur if two similar electrodes are employed, since these electrodes may be used asymmetrically. As a consequence, one electrode may still work under its design conditions in a proper way, while the other electrode suffers either from arc jumping since it is too cold, or from "burning back" since it is too hot.

**[0005]** There is a variety of factors which may lead to an asymmetry between two electrodes of a discharge lamp.

**[0006]** Firstly, a discharge lamp is usually employed in a reflector, which reflector may act as a cooling fin for the lamp. Depending on the mounting of the lamp in the reflector, one end of the lamp, and thus one electrode, may be cooled more than the other end with the other electrode.

**[0007]** Further, an increasing amount of UHP lamps is operated with a forced air cooling. This cooling is usually directed to the front end of the lamp or to the upper side of the lamp. Depending on the details of this airflow, highly different electrode temperatures can be observed.

**[0008]** Current UHP lamps are moreover designed to be operated in a horizontal burning position. Some applications, however, use the lamp in a tilted or even vertical position. As a result, the two electrodes receive a different heat load by the convective upwards flow of hot gas, and therefore they reach different temperatures.

**[0009]** During the lifetime of a discharge lamp, also the structure of the electrodes may change due to mechanical movements of parts of the electrodes, e.g. of the coil on the rod. Even in new lamps, the structure of the electrodes may vary due to tolerances. In case one of the electrodes already started to "bum back", its abilities to conduct and to emit heat change, and the process may speed up leading to an early lamp failure.

**[0010]** Most of these asymmetries cannot be compensated by using different electrodes, because they are unpredictable. Different electrodes further prevent a general use of the lamps and require additional care when inserting the lamp into the system in which it is employed.

**[0011]** It is an object of the invention to increase the performance and the lifetime of discharge lamps. It is in particular an object of the invention to provide a possibility of maintaining a temperature balance between two electrodes of a discharge lamp.

**[0012]** These objects are reached according to the invention with a method for operating a discharge lamp including two electrodes, which method comprises applying to the electrodes an alternating current. It is proposed that this alternating current has a direct current component for compensating a temperature difference between the two electrodes. The direct current component is selected to this end such that a first one of the electrodes, which is expected to have a lower temperature than the second one of the electrodes, functions as anode for the direct current component, while the second electrode functions as cathode for the direct current component.

**[0013]** The objects of the invention are equally reached with a driver employed for operating a discharge lamp with two electrodes, which driver comprises a power supply circuit comprising a power supply unit for providing a controllable direct current, and a controllable inverter for transforming the direct current into an alternating current to operate the lamp. The driver according to the invention further comprises a voltage detector for detecting a lamp voltage, and a processing means for controlling the power supply circuit on the basis of the measured lamp voltage by adjusting the alternating current to comprise a direct current component for compensating a temperature difference between the two electrodes, wherein the direct current component is selected such that a first one of said electrodes, which is expected to have a lower temperature than the second one of said electrodes, functions as anode for said direct current component, while said second electrode functions as cathode for said direct current component. Further, the objects of the invention are reached with a software program for operating a discharge lamp with two electrodes, which software program comprises a software code realizing the proposed method when run in a processing means of a driver controlling the power supply to the discharge lamp. Finally, the objects of the invention are reached with a lighting system, for instance a projection system, which comprises a discharge lamp with two electrodes and a driver according to the invention.

**[0014]** The two electrodes of the discharge lamp that is to be operated can be in particular, though not necessarily, similar electrodes.

**[0015]** The invention proceeds from the recognition that an electrode is heated more if it acts like an anode and is heated less if it acts like a cathode. Therefore, it is proposed to operate a discharge lamp with an alternating current which has a direct current component, the direct current component being used for balancing the temperature of the two electrodes.

**[0016]** It is an advantage of the invention that it allows to operate a discharge lamp such that both electrodes will run at the same temperature, which enables the setting of an optimum temperature for both electrodes. Thereby, arc jumping and a "burning back" of the electrodes can be avoided. As a result, the performance of a gas discharge lamp will be improved and its lifetime be increased for the case that the lamp operated in an asymmetric manner.

**[0017]** Preferred embodiments of the invention become apparent from the dependent claims.

**[0018]** The desired DC component of the alternating current applied to the electrodes of the discharge lamp can be achieved in several ways.

**[0019]** In a first preferred embodiment of the invention, the DC component is obtained by superimposing a DC current to the standard AC lamp current.

**[0020]** In a second preferred embodiment of the invention, the DC component is obtained by using a different strength of the AC current for the two current directions.

**[0021]** In a third preferred embodiment of the invention, the DC component is obtained by changing the time during which the lamp is operated in the two current directions. While in a standard AC operation, the waveform of the alternating current has a duty cycle with two half cycles of equal length for the two current directions, the proposed adjustment thus results in an operation with a duty cycle deviating from the standard 50:50 situation.

**[0022]** In a fourth preferred embodiment of the invention, the DC component is obtained by adapting the energy content of one or more additional pulses employed in each half cycle of the alternating current in a way that the energy content of these additional pulses is larger in one current direction than in the other. The energy content of such additional pulses can be adapted in particular by adapting the amplitude and/or the time of the additional current pulse or pulses individually for each half-cycle.

**[0023]** The amount of the DC component employed for balancing the temperature lies preferably in the range of 0.1% to 50% of the total current amount.

**[0024]** The expected temperature situation can equally be determined in different ways.

**[0025]** In case the asymmetrical heating of the electrodes is expected to be basically constant during the life time of the lamp, e.g. due to a predetermined orientation of the lamp or due to the arrangement of means producing a cooling air flow, it might be sufficient to predetermine the required amount of the DC component with some sample lamps. This amount can then be set as a fixed DC component for the lamp power supply.

**[0026]** In case the asymmetrical heating of the electrodes is not constant during the life time of the lamp, e.g. due to changing operating conditions or due to a changing electrode structure, the temperature situation of the electrodes is advantageously supervised individually for each lamp during its entire lifetime. The required amount of the DC component can then be determined continuously or repeatedly based on the respective temperature situation.

**[0027]** For determining the temperature situation in a rather simple way, the lamp burning voltage can be measured by the driver of the lamp at several times, i.e. at least twice, during one half cycle of the alternating current supplied to the lamp. If the measured voltage is slightly increasing during one half cycle, the electrode acting as a cathode in this half cycle can be assumed to be hot enough. If the voltage is decreasing or shows a sudden drop during one half cycle, in contrast, the electrode acting as a cathode in this half cycle can be assumed to be too cold. As only the respective cathode causes these voltage changes, both electrodes can be observed independently when taking into account the alternating current direction. A corresponding detection of electrodes that have to be considered to be too cold has also been described in document US 6,232,725.

**[0028]** The method according to the invention can further be integrated into a control loop controlling the current supply to the lamp and adjusting the DC component continuously.

**[0029]** Moreover, information about the adjusted DC component can be stored in a non volatile memory, e.g.

only the last applied value or more extensive information like the entire lamp history. The information can comprise for example the value of the respectively employed DC component, determined temperatures or temperature differences, or determined lamp voltages. The stored information can then be used for future predictions of the required amount of the DC component.

**[0030]** In order to operate both electrodes always at an optimum temperature, in addition an adjustment of the average lamp power should be enabled, e.g. for the case that both electrodes are too cold or hot enough. This aspect may also be included in a provided control loop. Thereby, an arc jumping at both electrodes and a "burning back" of both electrodes in case of a balanced but non-optimum temperature can be avoided.

**[0031]** The operated discharge lamp can be in particular a UHP lamp, but equally any other discharge lamp.

**[0032]** The method according to the invention can be implemented in an electronic circuit employed for operating the discharge lamp.

**[0033]** The method according to the invention can be realized in particular by software, which may be implemented e.g. in a micro-controller controlling the driver of the discharge lamp.

**[0034]** Other objects and features of the present invention will become apparent from the following detailed description of selected embodiments of the invention considered in conjunction with the accompanying drawings, wherein

- Fig. 1 shows a block diagram of a part of an embodiment of a projection system according to the invention;
- Fig. 2 shows an alternating block current without a direct current component;
- Fig. 3 shows an alternating block current with current pulses without a direct current component;
- Fig. 4 shows an alternating block current with a superimposed direct current;
- Fig. 5 shows an alternating block current with an asymmetrical duty cycle;
- Fig. 6 shows an alternating block current with amplitude modulated current pulses; and
- Fig. 7 shows an alternating block current with time modulated current pulses.

**[0035]** Figure 1 shows in form of a block diagram components of a of projection system in which an embodiment of the method according to the invention may be implemented.

**[0036]** The projection system comprises a UHP lamp 11 which is to be operated according to the invention. Two electrodes 12, 13 of the UHP lamp 11 are connected to this end to a controllable power supply circuit 14. The power supply circuit 14 may comprise in particular a power supply unit providing a direct current of a controllable value, and a controllable inverter transforming the provided direct current into an alternating current $I_{Lamp}$ desired for operating the lamp 11.

**[0037]** The power supply circuit 14 is controlled by a micro-controller 15. The micro-controller 15 comprises a software, which is able to control the power supply circuit 14 in a conventional manner. That is, the software causes the power supply circuit 14 to supply an alternating current $I_{Lamp}$ to the UHP lamp 11 which is suited to establish and maintain an arc between the two electrodes 12, 13. The software is in addition able to adjust the conventionally supplied alternating current to comprise a desired direct current component.

**[0038]** The micro-controller 15 further comprises a non-volatile memory. In this memory, the history of the provided direct current components is stored. The micro-controller 15 receives as input information on the current lamp voltage via a voltage detector 16 detecting the respective voltage $U_{Lamp}$ over the UHP lamp 11. Power supply circuit 14, micro-controller 15 and voltage detector 16 constitute together the driver of the UHP lamp 11.

**[0039]** The software of the micro-controller adjusts the direct current component of the current $I_{Lamp}$ supplied by the power supply circuit 14 in a control loop. In this control loop, the software first evaluates information on the lamp voltage received by the voltage detector 16. The lamp burning voltage $U_{Lamp}$ is measured by the voltage detector 16 repeatedly during each half cycle of the alternating current supplied to the lamp 11. If this voltage $U_{Lamp}$ is determined by the software to be increasing during one half cycle, the electrode 12, 13 acting in this half cycle as a cathode is hot enough. If the voltage is determined by the software to be decreasing or to show a sudden drop during one half cycle, the electrode 12, 13 acting in this half cycle as a cathode is too cold.

**[0040]** Based on this evaluation, the software then adjusts its conventional control of the power supply circuit 14 and thus of the conventionally supplied alternating current. That is, in case it is determined that one electrode 12, 13 is too cold, the direct current component is increased in a sense that this electrode 12, 13 acts more as an anode than before. In case it is determined that both electrodes 12, 13 are hot enough, in contrast, the direct current component is lowered in order to approach a pure alternating current operation. Further below, four different solutions for adjusting the conventional alternating current to comprise a direct current component will be presented with reference to figures 2 to 7.

**[0041]** In addition, the entire average lamp power is increased in the control loop, in case it is determined that both electrodes 12, 13 are too cold. In case it is determined that both electrodes 12, 13 are hot enough, while it can be concluded from the lamp history stored in the memory of the micro-controller 15 that both electrodes do not tend to approach the critical temperature boundary, the average lamp power is lowered.

**[0042]** Thus, the presented system allows to operate both electrodes 12, 13 of the UHP lamp 11 always at an optimum temperature.

**[0043]** Figures 2 to 7 are diagrams depicting different lamp currents $I_{Lamp}$ over time t.

**[0044]** Figures 2 and 3 illustrate the course of alternating currents $I_{Lamp}$ supplied conventionally to a UHP lamp 11. Figure 2 shows a standard block current. In this block current, each duty cycle has two half cycles I, II of the same length, during which a constant current of the same amplitude but opposed polarity is provided. The half cycle I with a positive current will also be referred to as positive half cycle, and the half cycle II with a negative current will also be referred to as negative half cycle. Figure 3 shows a similar standard block current, in which an additional current pulse P1, P2 having the same polarity as the regular block current is added at the end of each half cycle I, II. The use of such a current comprising additional pulses is known for instance from document EP 0 766 906 A. As can be seen in figures 2 and 3, the conventional alternating current does not have any direct current component. Such a conventional current is also supplied by the power supply 14 of figure 1 to the UHP lamp 11, in case the micro-controller 15 determines that the both electrodes 12, 13 are currently hot enough, or that both electrodes 12, 13 are too cold and that thus only the total average power has to be increased.

**[0045]** Different possibilities for adjusting the direct current component of the supplied alternating current to a desired value when proceeding from one of the conventionally supplied alternating currents illustrated in figures 2 and 3 are illustrated in figures 4 to 7.

**[0046]** In the solution presented in figure 4, a desired direct current is simply superimposed to the provided alternating block current of figure 2. The additional direct current is provided by the power supply circuit 14 according to control signals by the micro-controller 15. In the depicted situation, a positive direct current is superimposed to the conventional alternating current. As a result, the alternating current $I_{Lamp}$ provided to the lamp comprises a positive direct current component DC corresponding to the superimposed direct current, as indicated in the figure. The same effect can be reached without additional means for superimposing a direct current, and thus without a change of the structure of the conventionally used power supply, by using a different current strength in both directions of the conventional alternating current.

**[0047]** Figure 5 proceeds equally from the standard alternating block current depicted in figure 2. In the solution presented in figure 5, a direct current component is achieved by increasing the length of the one of the half cycles of a duty cycle of the conventional alternating current and by reducing the length of the other one of the half cycles of the duty cycle. The length of the half cycles is set in the power supply circuit 14 according to control signals by the micro-controller 15. In the depicted situation, the respective positive half cycle I is longer than the respective negative half cycle II. As a result, the alternating current comprises the positive direct current component DC indicated in the figure.

**[0048]** Figure 6 proceeds from the standard alternating block current with additional current pulses depicted in figure 3. In the solution presented in figure 6, a direct current component is achieved by modulating the amplitude of the additional current pulses in each half cycle. The modulation of the amplitude of the additional current pulses is set in the power supply circuit 14 according to control signals by the micro-controller 15. In the depicted situation, the additional current pulse P 1 in the positive half cycle I has a larger amplitude than the additional current pulse P2 in the negative half cycle II. As a result, the alternating current comprises the positive direct current component DC indicated in the figure.

**[0049]** Figure 7 proceeds again from the standard alternating block current with additional current pulses depicted in figure 3. In the solution presented in figure 7, a direct current component is achieved by modulating the time of the additional current pulses in each half cycle. The modulation of the time of the additional current pulses is set in the power supply circuit 14 according to control signals by the micro-controller 15. In the depicted situation, the additional current pulse P1 in the positive half cycle I has a longer duration than the additional current pulse P2 in the negative half cycle II. As a result, the alternating current comprises the positive direct current component DC indicated in the figure.

**[0050]** It is to be noted that the presented embodiments of the invention constitute only selected embodiments which can be varied in many ways.

## Claims

1. Method for operating a discharge lamp (11) including two electrodes (12,13), said method comprising applying to said electrodes (12,13) an alternating current ($I_{Lamp}$), which alternating current ($I_{Lamp}$) has a direct current component (DC), **characterized in that** said direct current component (DC) compensates a temperature difference between said two electrodes (12,13), wherein said direct current component (DC) is selected such that a first one of said electrodes (12,13), which is expected to have a lower temperature than the second one of said electrodes (13,12), functions as anode for said direct current component (DC), while said second electrode (13,12) functions as cathode for said direct current component (DC).

2. Method according to claim 1, wherein said direct current component (DC) constitutes 0.1% to 50% of the total current ($I_{Lamp}$).

3. Method according to claim 1 or 2, wherein said direct current component (DC) is obtained by superimposing a direct current to an alternating lamp current.

4. Method according to one of the preceding claims, wherein said direct current component (DC) is ob-

tained by providing a different current strength in both directions of the alternating current ($I_{Lamp}$).

**5.** Method according to one of the preceding claims, wherein said direct current component (DC) is obtained by providing to said discharge lamp (11) an alternating current with a duty cycle of which the half cycles (I) with a positive current have a different length than the half cycles (II) with a negative current.

**6.** Method according to one of the preceding claims, wherein said direct current component (DC) is obtained by supplying one or more additional current pulses (P1,P2) to each half cycle (I,II) of the duty cycle of said alternating current, and wherein the energy content of said additional current pulses (P1,P2) is controlled in a way that it is larger in one of said half cycles (I,II) than in the other.

**7.** Method according to one of the preceding claims, wherein said direct current component (DC) is determined according to a temperature difference expected between said electrodes (12,13) due to a non-horizontal burning position of said discharge lamp (11).

**8.** Method according to one of the preceding claims, wherein said direct current component (DC) is determined according to a temperature difference expected between said electrodes (12,13) due to an unequal cooling of said electrodes (12,13).

**9.** Method according to one of the preceding claims, wherein said direct current component (DC) is predetermined for the entire time of operation of said discharge lamp (11).

**10.** Method according to one of claims 1 to 8, wherein said direct current component (DC) is adjusted during the operation of said discharge lamp (11) based on measurements indicative of an expected temperature difference between said electrodes (12,13).

**11.** Method according to claim 10, wherein for said measurements, the voltage ($U_{Lamp}$) over said discharge lamp (11) is measured at least twice during a respective half cycle (I,II) of the duty cycle of an alternating current ($I_{Lamp}$) supplied to said discharge lamp (11), and wherein a detected increasing voltage during one half cycle (I,II) is taken as indication that the electrode (12,13) acting as a cathode in this half cycle (I,II) is hot enough, while a decreasing voltage or a sudden drop of voltage during one half cycle (I, II) is taken as indication that the electrode (12,13) acting as a cathode in this half cycle (I,II) is too cold.

**12.** Method according to claim 10 to 11, wherein said direct current component (DC) is adjusted during the operation of said discharge lamp (11) in a control loop, in which control loop the value of said direct current component (DC) is respectively adapted to provide more anodic current to an electrode (12,13) which was determined to be too cold and to have a lower temperature than said other electrode (13,12).

**13.** Method according to one of claims 10 to 12, wherein said direct current component (DC) is adjusted during the operation of said discharge lamp (11) in a control loop, in which control loop the value of said direct current component (DC) is decreased, in case both of said electrodes (12,13) were determined to be hot enough.

**14.** Method according to one of claims 10 to 13, wherein the total power provided to said discharge lamp (11) is increased, in case both of said electrodes (12,13) are determined to be too cold.

**15.** Method according to one of claims 10 to 14, wherein the total power provided to said discharge lamp (11) is decreased, in case both of said electrodes (12,13) are determined to be hot enough.

**16.** Method according to one of claims 10 to 15, wherein information on the carried out adjustments of the direct current component (DC) is recorded in a non-volatile memory for supporting future adjustments of a direct current component (DC).

**17.** A driver (14,15,16) for operating a discharge lamp (11) including two electrodes (12,13), which driver comprises

- a power supply circuit (14) comprising a power supply unit for providing a controllable direct current, and a controllable inverter for transforming the direct current into an alternating current ($I_{Lamp}$) to operate the lamp (11);
- a voltage detector (16) for detecting a lamp voltage ($U_{Lamp}$);
- and a processing means (15) for controlling the power supply circuit (14) on the basis of the measured lamp voltage ($U_{Lamp}$) by adjusting the alternating current ($I_{Lamp}$) to comprise a direct current component for compensating a temperature difference between said two electrodes (12,13), wherein said direct current component (DC) is selected such that a first one of said electrodes (12,13), which is expected to have a lower temperature than the second one of said electrodes (13,12), functions as anode for said direct current component (DC), while said second electrode (13,12) functions as cathode for said direct current component (DC).

**18.** Software program for operating a discharge lamp (11) with two electrodes (12,13), which software program comprises a software code realizing the method according to one of claims 1 to 16 when run in processing means (15) of a driver (14,15,16) controlling the power supply to said discharge lamp (11).

**19.** Lighting system comprising a discharge lamp (11) with two electrodes (12,13) and a driver (14,15,16) according to claim 17.

**20.** Lighting system according to claim 19, which enables different burning positions for said discharge lamp (11).

**21.** Lighting system according to claim 19 or 20, in which system said discharge lamp (11) is arranged such that one of said electrodes (12,13) is cooled more than the other one of said electrodes (12,13) during the operation of said lighting system.

**22.** Lighting system according to one of claims 19 to 21, which system is a projection system.

**Patentansprüche**

**1.** Verfahren zum Betreiben einer Entladungslampe (11) mit zwei Elektroden (12,13), wobei das Verfahren das Anlegen eines Wechselstroms ($I_{Lamp}$), an die Elektroden umfasst, wobei der Wechselstrom ($I_{Lamp}$) eine Gleichstromkomponente (DC) aufweist, **dadurch gekennzeichnet, dass** die Gleichstromkomponente (DC) einen Temperaturunterschied zwischen den beiden Elektroden (12,13) ausgleicht, wobei die Gleichstromkomponente (DC) so gewählt wird, dass eine erste der Elektroden (12,13), von der erwartet wird, dass sie eine niedrigere Temperatur als die zweite der Elektroden (13,12) aufweist, als Anode für die Gleichstromkomponente (DC) wirkt, während die zweite Elektrode (13,12) als Katode für die Gleichstromkomponente (DC) wirkt.

**2.** Verfahren nach Anspruch 1, wobei die Gleichstromkomponente (DC) 0,1% bis 50% des Gesamtstroms ($I_{Lamp}$) darstellt.

**3.** Verfahren nach Anspruch 1 oder 2, wobei die Gleichstromkomponente (DC) erhalten wird, indem ein Gleichstrom einem Lampenwechselstrom überlagert wird.

**4.** Verfahren nach einem der vorangegangenen Ansprüche, wobei die Gleichstromkomponente (DC) erhalten wird, indem eine unterschiedliche Stromstärke in beiden Richtungen des Wechselstroms ($I_{Lamp}$) vorgesehen wird.

**5.** Verfahren nach einem der vorangegangenen Ansprüche, wobei die Gleichstromkomponente (DC) erhalten wird, indem der Entladungslampe (11) ein Wechselstrom mit einem Tastverhältnis zugeführt wird, dessen Halbperioden (I) mit einem positiven Strom eine andere Länge als die Halbperioden (II) mit einem negativen Strom aufweisen.

**6.** Verfahren nach einem der vorangegangenen Ansprüche, wobei die Gleichstromkomponente (DC) erhalten wird, indem jeder Halbperiode (I,II) des Tastverhältnisses des Wechselstroms einer oder mehrere zusätzliche Stromimpulse (P1,P2) zugeführt werden und wobei der Energiegehalt der zusätzlichen Stromimpulse (P1,P2) so gesteuert wird, dass er in einer der Halbperioden (I,II) größer als in der anderen ist.

**7.** Verfahren nach einem der vorangegangenen Ansprüche, wobei die Gleichstromkomponente (DC) gemäß einem Temperaturunterschied bestimmt wird, welcher zwischen den Elektroden (12,13) infolge einer nicht horizontalen Brennlage der Entladungslampe (11) erwartet wird.

**8.** Verfahren nach einem der vorangegangenen Ansprüche, wobei die Gleichstromkomponente (DC) gemäß einem Temperaturunterschied bestimmt wird, welcher zwischen den Elektroden (12,13) infolge einer ungleichen Abkühlung der Elektroden (12,13) erwartet wird.

**9.** Verfahren nach einem der vorangegangenen Ansprüche, wobei die Gleichstromkomponente (DC) für die gesamte Dauer des Betriebs der Entladungslampe (11) vorher festgelegt wird.

**10.** Verfahren nach einem der Ansprüche 1 bis 8, wobei die Gleichstromkomponente (DC) während des Betriebs der Entladungslampe (11) aufgrund von Messungen, die für einen erwarteten Temperaturunterschied zwischen den Elektroden (12,13) beispielhaft sind, eingestellt wird.

**11.** Verfahren nach Anspruch 10, wobei die Spannung ($U_{Lamp}$) an der Entladungslampe (11) für die Messungen mindestens zweimal während einer jeweiligen Halbperiode (I,II) des Tastverhältnisses eines der Entladungslampe (11) zugeführten Wechselstroms ($I_{Lamp}$) gemessen wird, und wobei eine detektierte, ansteigende Spannung während einer Halbperiode (I,II) als Hinweis darauf angesehen wird, dass die in dieser Halbperiode (I,II) als Katode wirkende Elektrode (12,13) heiß genug ist, während eine abfallende Spannung oder ein plötzlicher Spannungsabfall während einer Halbperiode (I,II) als Hinweis darauf angesehen wird, dass die in dieser Halbperiode (I,II) als Katode wirkende Elektrode (12,13) zu kalt ist.

**12.** Verfahren nach Anspruch 10 oder 11, wobei die Gleichstromkomponente (DC) während des Betriebs der Entladungslampe (11) in einer Regelschleife eingestellt wird, wobei in der Regelschleife der Wert der Gleichstromkomponente (DC) jeweils so angepasst wird, dass einer Elektrode (12,13), die als zu kalt und mit einer niedrigeren Temperatur als die andere Elektrode (13,12) ermittelt wurde, mehr Anodenstrom zugeführt wird.

**13.** Verfahren nach einem der Ansprüche 10 bis 12, wobei die Gleichstromkomponente (DC) während des Betriebs der Entladungslampe (11) in einer Regelschleife eingestellt wird, wobei in der Regelschleife der Wert der Gleichstromkomponente (DC) verringert wird, im Falle ermittelt wurde, dass beide Elektroden (12,13) heiß genug sind.

**14.** Verfahren nach einem der Ansprüche 10 bis 13, wobei die der Entladungslampe (11) zugeführte Gesamtenergie erhöht wird, im Falle ermittelt wurde, dass beide der Elektroden (12,13) zu kalt sind.

**15.** Verfahren nach einem der Ansprüche 10 bis 14, wobei die der Entladungslampe (11) zugeführte Gesamtenergie verringert wird, im Falle ermittelt wurde, dass beide der Elektroden (12,13) heiß genug sind.

**16.** Verfahren nach einem der Ansprüche 10 bis 15, wobei Informationen über die durchgeführten Einstellungen der Gleichstromkomponente (DC) in einem nicht flüchtigen Speicher registriert werden, um künftige Einstellungen einer Gleichstromkomponente (DC) zu unterstützen.

**17.** Treiber (14,15,16) zum Betreiben einer Entladungslampe (11) mit zwei Elektroden (12,13), welcher umfasst:

- eine Stromversorgungsschaltung (14) mit einer Stromversorgungseinheit zur Abgabe eines regelbaren Gleichstroms sowie einem regelbaren Wechselrichter zur Umwandlung des Gleichstroms in einen Wechselstrom ($I_{Lamp}$), um die Lampe (11) zu betreiben,
- einen Spannungsdetektor (16) zum Detektieren einer Lampenspannung ($U_{Lamp}$), sowie
- ein Verarbeitungsmittel (15) zur Steuerung der Stromversorgungsschaltung (14) aufgrund der gemessenen Lampenspannung ($U_{Lamp}$), indem der Wechselstrom ($I_{Lamp}$) so eingestellt wird, dass er eine Gleichstromkomponente aufweist, um einen Temperaturunterschied zwischen den beiden Elektroden (12,13) auszugleichen, wobei die Gleichstromkomponente (DC) so gewählt wird, dass eine erste der Elektroden (12,13), von der erwartet wird, dass sie eine niedrigere Temperatur als die zweite der Elektroden (13,12) aufweist, als Anode für die Gleichstromkomponente (DC) wirkt, während die zweite Elektrode (13,12) als Katode für die Gleichstromkomponente (DC) wirkt.

**18.** Softwareprogramm zum Betreiben einer Entladungslampe (11) mit zwei Elektroden (12,13), welches einen Softwarecode aufweist, mit dem das Verfahren nach einem der Ansprüche 1 bis 16 realisiert wird, wenn dieses in dem die Stromzufuhr zu der Entladungslampe (11) regelnden Verarbeitungsmittel (15) eines Treibers (14,15,16) abläuft.

**19.** Beleuchtungssystem mit einer Entladungslampe (11) mit zwei Elektroden (12,13) und einem Treiber (14,15,16) nach Anspruch 17.

**20.** Beleuchtungssystem nach Anspruch 19, welches verschiedene Brennlagen bei der Entladungslampe (11) ermöglicht.

**21.** Beleuchtungssystem nach Anspruch 19 oder 20, in welchem die Entladungslampe (11) so angeordnet ist, dass eine der Elektroden (12,13) während des Betriebs des Beleuchtungssystems mehr als die andere der Elektroden (12,13) gekühlt wird.

**22.** Beleuchtungssystem nach einem der Ansprüche 10 bis 21, welches ein Projektionssystem ist.

## Revendications

**1.** Procédé pour faire fonctionner une lampe à décharge (11) comprenant deux électrodes (12, 13), ledit procédé comprenant l'application auxdites électrodes (12, 13) d'un courant alternatif ($I_{Lamp}$), lequel courant alternatif ($I_{Lamp}$) a une composante de courant continu (CC), **caractérisé en ce que** ladite composante de courant continu (CC) compense une différence de température entre lesdites deux électrodes (12, 13), où ladite composante de courant continu (CC) est sélectionnée telle qu'une première desdites électrodes (12, 13), qui est escomptée avoir une température plus basse que la deuxième desdites électrodes (13, 12), fonctionne comme une anode pour ladite composante de courant continu (CC), alors que ladite deuxième électrode (13, 12) fonctionne comme une cathode pour ladite composante de courant continu (CC).

**2.** Procédé selon la revendication 1, dans lequel ladite composante de courant continu (CC) constitue de 0,1 % à 50% du courant ($I_{Lamp}$) total.

**3.** Procédé selon la revendication 1 ou 2, dans lequel ladite composante de courant continu (CC) est obtenue en superposant un courant continu à un courant de lampe alternatif.

**4.** Procédé selon l'une quelconque des revendications précédentes, dans lequel ladite composante de courant continu (CC) est obtenue en procurant une intensité de courant différente dans les deux directions du courant alternatif ($I_{Lamp}$).

**5.** Procédé selon l'une quelconque des revendications précédentes, dans lequel ladite composante de courant continu (CC) est obtenue en procurant à ladite lampe à décharge (11) un courant alternatif avec un rapport cyclique duquel les demi-cycles avec un courant positif (I) ont une longueur différente des demi-cycles avec un courant négatif (II).

**6.** Procédé selon l'une quelconque des revendications précédentes, dans lequel ladite composante de courant continu (CC) est obtenue en fournissant une ou plusieurs impulsions de courant additionnelles (P1, P2) à chaque demi-cycle (I, II) du rapport cyclique dudit courant alternatif, et dans lequel le contenu en énergie desdites impulsions de courant additionnelles (P1, P2) est commandé d'une façon qui est plus grande dans un desdits demi-cycles (I, II) que dans l'autre.

**7.** Procédé selon l'une quelconque des revendications précédentes, dans lequel ladite composante de courant continu (CC) est déterminée en fonction d'une différence de température escomptée entre lesdites électrodes (12, 13) du fait d'une position d'allumage non horizontale de ladite lampe à décharge (11).

**8.** Procédé selon l'une quelconque des revendications précédentes, dans lequel ladite composante de courant continu (CC) est déterminée selon l'une différence de température escomptée entre lesdites électrodes (12, 13) du fait d'un refroidissement inégal desdites électrodes (12,13).

**9.** Procédé selon l'une quelconque des revendications précédentes, dans lequel ladite composante de courant continu (CC) est prédéterminée pour la durée de fonctionnement complète de ladite lampe à décharge (11).

**10.** Procédé selon l'une quelconque des revendications 1 à 8, dans lequel ladite composante de courant continu (CC) est ajustée pendant le fonctionnement de ladite lampe à décharge (11) sur base de mesures indicatives d'une différence de température escomptée entre lesdites électrodes (12, 13).

**11.** Procédé selon la revendication 10, dans lequel, pour lesdites mesures, la tension ($U_{Lamp}$) appliquée à ladite lampe à décharge (11) est mesurée au moins deux fois pendant un demi-cycle respectif (I, II) du rapport cyclique d'un courant alternatif ($I_{Lamp}$) fourni à ladite lampe à décharge (11), et dans lequel une augmentation de tension détectée pendant un demi-cycle (I, II) est prise comme une indication de ce que l'électrode (12, 13) agissant comme une cathode dans ce demi-cycle (I, II) est suffisamment chaude, alors qu'une tension décroissante ou une chute de tension soudaine pendant un demi-cycle (I, II) est prise comme une indication de ce que l'électrode (12, 13) agissant comme une cathode dans ce demi-cycle (I, II) est trop froide.

**12.** Procédé selon la revendication 10 ou 11, dans lequel ladite composante de courant continu (CC) est ajustée dans une boucle de commande pendant le fonctionnement de ladite lampe à décharge (11), dans laquelle boucle de commande la valeur de ladite composante de courant continu (CC) est respectivement adaptée pour procurer plus de courant anodique à une électrode (12, 13) qui est déterminée être trop froide et avoir une température plus basse que ladite autre électrode (13, 12).

**13.** Procédé selon l'une quelconque des revendications 10 à 12, dans lequel ladite composante de courant continu (CC) est ajustée dans une boucle de commande pendant le fonctionnement de ladite lampe à décharge (11), dans laquelle boucle de commande la valeur de ladite composante de courant continu (CC) est diminuée dans le cas où les deux desdites électrodes (12, 13) sont déterminées être suffisamment chaudes.

**14.** Procédé selon l'une quelconque des revendications 10 à 13, dans lequel l'énergie totale procurée à ladite lampe à décharge (11) est augmentée dans le cas où les deux desdites électrodes (12, 13) sont déterminées être trop froides.

**15.** Procédé selon l'une quelconque des revendications 10 à 14, dans lequel l'énergie totale procurée à ladite lampe à décharge (11) est diminuée dans le cas où les deux desdites électrodes (12, 13) sont déterminées être suffisamment chaudes.

**16.** Procédé selon l'une quelconque des revendications 10 à 15, dans lequel une information concernant les ajustements effectués de la composante de courant continu (CC) est enregistrée dans une mémoire non volatile pour alimenter des ajustements futurs d'une composante de courant continu (CC).

**17.** Circuit de commande (14,15, 16) pour faire fonctionner une lampe à décharge (11) qui comprend deux électrodes (12, 13), lequel circuit de commande comprend

- un circuit d'alimentation électrique (14) qui comprend une unité d'alimentation électrique pour procurer un courant continu réglable, et un onduleur qui peut être commandé pour transformer le courant continu en un courant alternatif ($I_{Lamp}$) pour faire fonctionner la lampe (11);
- un détecteur de tension (16) pour détecter une tension de lampe ($U_{Lamp}$);
- et un moyen de traitement (15) pour commander le circuit d'alimentation électrique (14) sur la base de la tension de lampe mesurée ($U_{Lamp}$), en ajustant le courant alternatif ($I_{Lamp}$) pour comprendre une composante de courant continu pour compenser une différence de température entre lesdites deux électrodes (12, 13), où ladite composante de courant continu (CC) est sélectionnée telle qu'une première desdites électrodes (12, 13), qui est escomptée avoir une température plus basse que la deuxième desdites électrodes (13, 12), fonctionne comme une anode pour ladite composante de courant continu (CC), alors que ladite deuxième électrode (13, 12) fonctionne comme une cathode pour ladite composante de courant continu (CC).

**18.** Programme informatique pour faire fonctionner une lampe à décharge (11) avec deux électrodes (12, 13), lequel programme informatique comprend un code logiciel qui réalise le procédé selon l'une quelconque des revendications 1 à 16 quand il est exécuté dans un moyen de traitement (15) d'un circuit de commande (14, 15, 16) qui commande l'alimentation électrique de ladite lampe à décharge (11).

**19.** Système d'éclairage comprenant une lampe à décharge (11) avec deux électrodes (12, 13) et un circuit de commande (14, 15, 16) selon la revendication 17.

**20.** Système d'éclairage selon la revendication 19, qui permet différentes positions d'allumage pour ladite lampe à décharge (11).

**21.** Système d'éclairage selon la revendication 19 ou 20, dans lequel système ladite lampe à décharge (11) est disposée de façon qu'une desdites électrodes (12, 13) est refroidie plus que l'autre desdites électrodes (12, 13) pendant le fonctionnement dudit système d'éclairage.

**22.** Système d'éclairage selon l'une quelconque des revendications 19 à 21, lequel système est un système de projection.

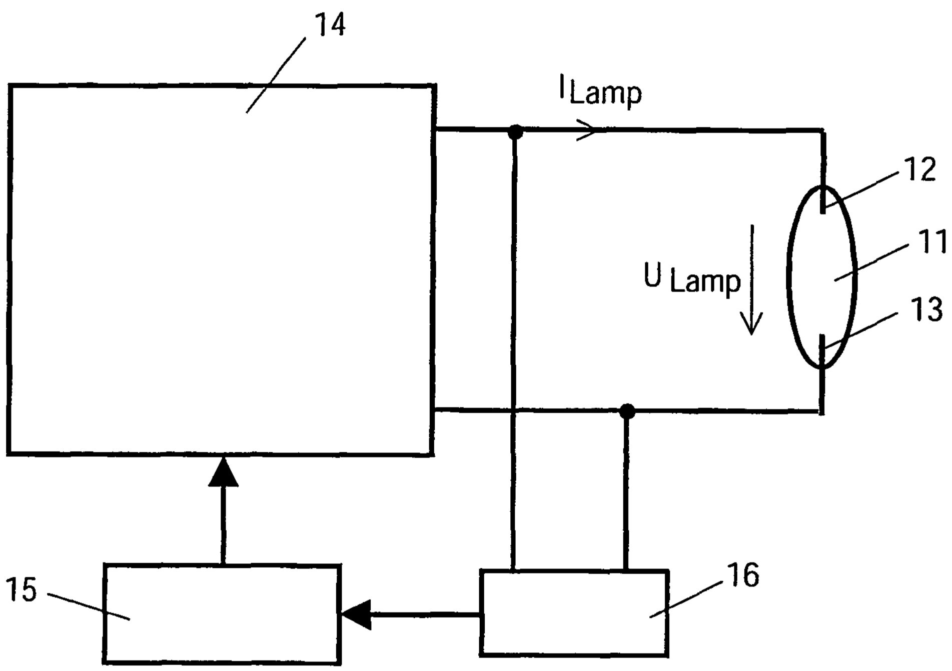


FIG.1

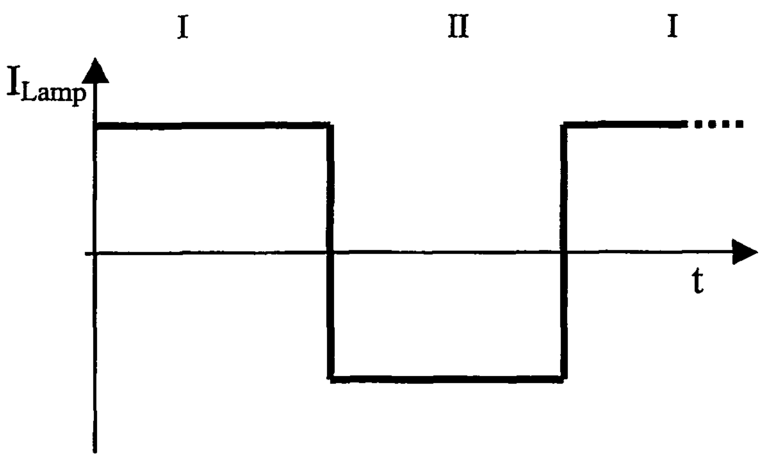


FIG.2

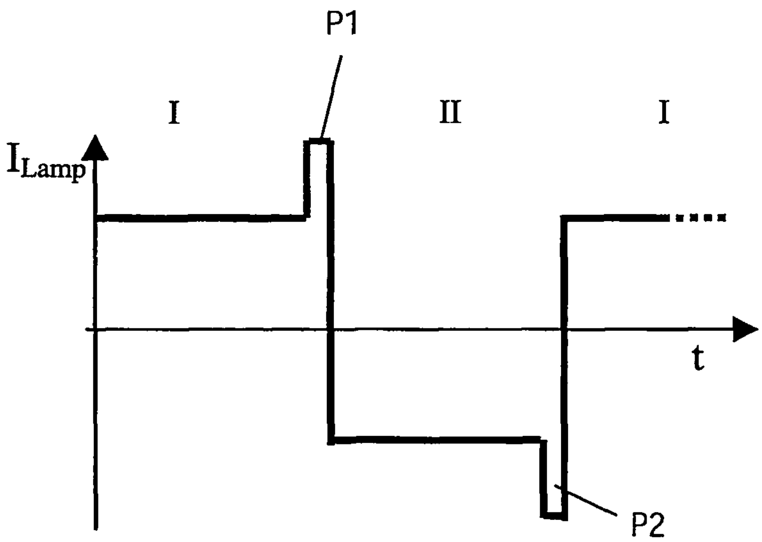


FIG.3

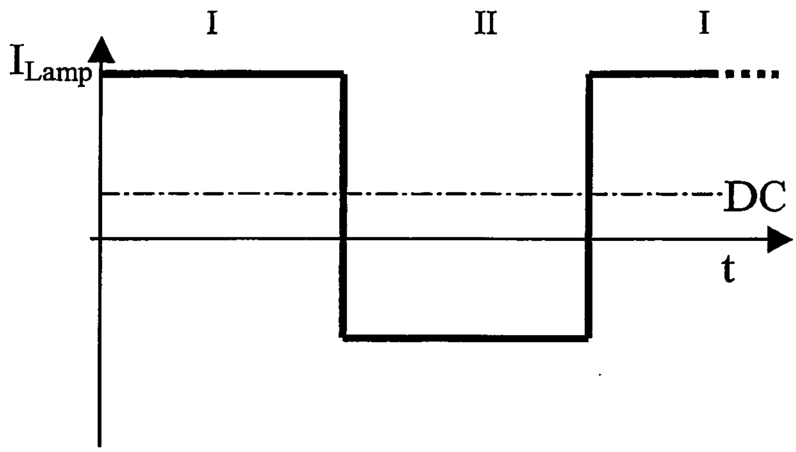


FIG.4

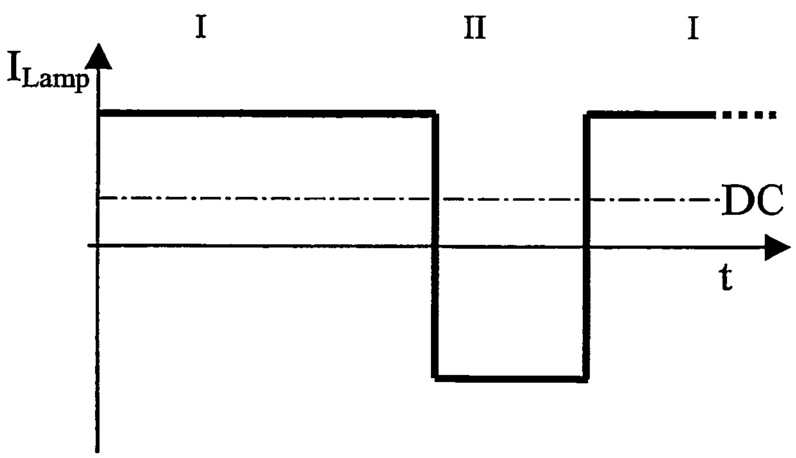


FIG.5

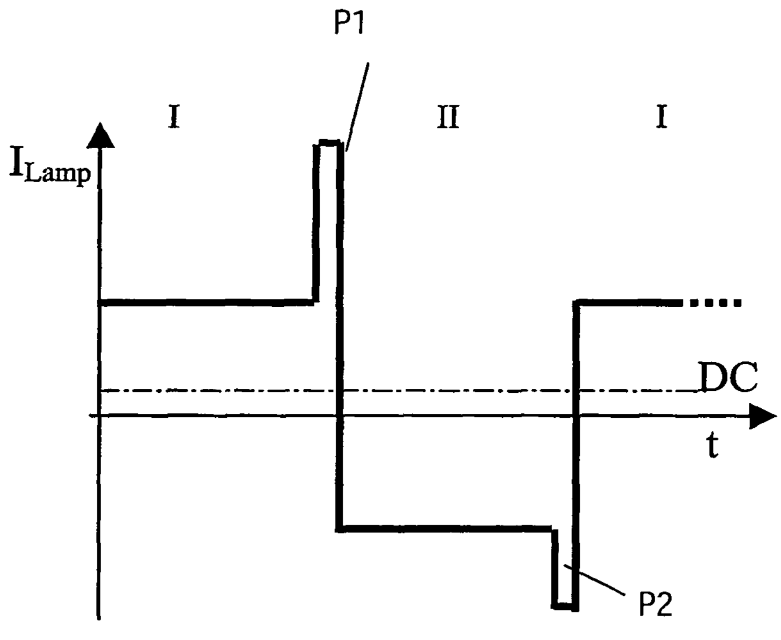


FIG.6

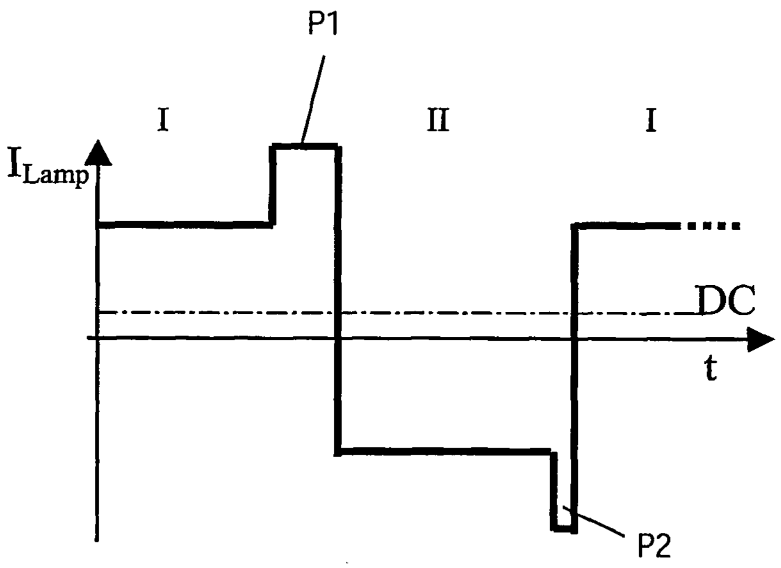


FIG.7

## REFERENCES CITED IN THE DESCRIPTION



### Patent documents cited in the description


- EP 0825807 A2 **[0003]**
- US 6232725 B1 **[0003]**
- US 6232725 B **[0027]**
- EP 0766906 A **[0044]**